CLAIMS

1. A reflective mask blank comprising a substrate on which a reflective layer for reflecting exposure light in a short-wavelength region including an extreme ultraviolet region and an absorber layer for absorbing the exposure light are successively formed, the absorber layer having an at least two-layer structure including as a lower layer an exposure light absorbing layer comprising an absorber for the exposure light and as an upper layer a low-reflectivity layer comprising an absorber for inspection light used in inspection of a mask pattern, the upper layer being farther from the substrate than the lower layer, wherein:

the upper layer is made of a material containing tantalum (Ta), boron (B), and nitrogen (N), the content of B being 5 at% to 30 at%, the ratio of Ta and N (Ta : N) falling within a range of 8 : 1 to 2 : 7.

2. A reflective mask blank comprising a substrate on which a reflective layer for reflecting exposure light in a short-wavelength region including an extreme ultraviolet region and an absorber layer for absorbing the exposure light are successively formed, the absorber layer having an at least two-layer structure including as a lower layer an exposure light absorbing layer comprising an absorber for the exposure light and as an upper layer a low-reflectivity layer comprising an absorber for inspection light used in inspection of a mask pattern, the upper layer being farther from the substrate than the lower layer, wherein:

the upper layer is made of a material containing tantalum (Ta), boron (B), and nitrogen (N) and having an amorphous state.

3. A reflective mask blank comprising a substrate on which a reflective layer for reflecting exposure light in a short-wavelength region including an extreme ultraviolet region and an absorber layer for absorbing the exposure

light are successively formed, the absorber layer having an at least two-layer structure including as a lower layer an exposure light absorbing layer comprising an absorber for the exposure light and as an upper layer a low-reflectivity layer comprising an absorber for inspection light used in inspection of a mask pattern, the upper layer being farther from the substrate than the lower layer, wherein:

the upper layer is made of a material containing tantalum (Ta), boron (B), and oxygen (O).

4. The reflective mask blank as claimed in claim 3, wherein the upper layer further contains nitrogen (N).

5. The reflective mask blank as claimed in any one of claims 2 through 4, wherein the upper layer contains 5-25 at% boron (B).

6. A reflective mask blank comprising a substrate on which a reflective layer for reflecting exposure light in a short-wavelength region including an extreme ultraviolet region and an absorber layer for absorbing the exposure light are successively formed, the absorber layer having an at least two-layer structure including as a lower layer an exposure light absorbing layer comprising an absorber for the exposure light and as an upper layer a low-reflectivity layer comprising an absorber for inspection light used in inspection of a mask pattern, the upper layer being farther from the substrate than the lower layer, wherein:

the upper layer is made of a material containing Ta, at least one of Si and Ge, and at least one of nitrogen and oxygen.

7 A reflective mask blank comprising a substrate on which a reflective layer for reflecting exposure light in a short-wavelength region including an extreme ultraviolet region and an absorber layer for absorbing the exposure light are successively formed, the absorber layer having an at least two-layer structure including as a lower layer an exposure light absorbing layer

comprising an absorber for the exposure light and as an upper layer a low-reflectivity layer comprising an absorber for inspection light used in inspection of a mask pattern, the upper layer being farther from the substrate than the lower layer, wherein:

the upper layer is formed by a substance containing Ta, nitrogen, and oxygen.

8. The reflective mask blank as claimed in any one of claims 3 through 7, wherein the material of the upper layer has an amorphous state. —

9. A reflective mask blank comprising a substrate on which a reflective layer for reflecting exposure light in a short-wavelength region including an extreme ultraviolet region and an absorber layer for absorbing the exposure light are successively formed, the absorber layer having an at least two-layer structure including as a lower layer an exposure light absorbing layer comprising an absorber for the exposure light and as an upper layer a low-reflectivity layer comprising an absorber for inspection light used in inspection of a mask pattern, the upper layer being farther from the substrate than the lower layer, wherein:

the low-reflectivity layer as the upper layer comprises:

at least one selected from a second group including:

one of nitride, oxide, and oxynitride of one element selected from a first group including chromium, manganese, cobalt, copper, zinc, gallium, germanium, molybdenum, palladium, silver, cadmium, tin, antimony, tellurium, iodine, hafnium, tungsten, titanium, and gold;

one of the nitride, the oxide, and the oxynitride with silicon added thereto;

one of nitride, oxide, and oxynitride of an alloy containing one element selected from the first group;

one of the nitride, the oxide, and the oxynitride of the alloy with silicon added thereto; and

silicon oxynitride.

10. The reflective mask blank as claimed in claim 9, wherein:

the exposure light absorbing layer as the lower layer comprises:

at least one selected from a third group including:

one element selected from the first group;

a substance containing at least one of nitrogen and oxygen and the selected one element;

an alloy containing one element selected from the first group; and

a substance containing at least one of nitrogen and oxygen and the alloy.

11. The reflective mask blank as claimed in any one of claims 1 through 9, wherein the exposure light absorbing layer as the lower layer is made of a material containing Ta.

12. The mask blank as claimed in claim 11, wherein the material of the exposure light absorbing layer as the lower layer further contains B.

13. The reflective mask blank as claimed in any one of claims 1 through 12, wherein an intermediate region where a composition is continuously varied from a composition of the lower layer to a composition of the upper layer is interposed between the lower layer and the upper layer.

14. The reflective mask blank as claimed in any one of claims 1 through 13, comprising a buffer layer interposed between the reflective layer and the absorber layer to protect the reflective layer during pattern formation on the absorber layer.

15. The reflective mask blank as claimed in claim 14, wherein the lower layer of the absorber layer is formed by a substance containing Ta, the buffer layer being formed by Cr or a substance containing Cr as a main component.

16. The reflective mask blank as claimed in any one of claims 1 through 15, wherein a contrast between reflected light reflected on a surface of the reflective layer and reflected light reflected on a surface of the absorber layer is 40 % or more at the wavelength of light used in inspection of a pattern

formed on the absorber layer.

17. The reflective mask blank as claimed in any one of claims 1 through 16, further comprising a buffer layer formed between the reflective layer and the absorber layer to protect the reflective layer during pattern formation on the absorber layer;

a contrast between reflected light reflected on a surface of the buffer layer and reflected light reflected on a surface of the absorber layer being 40 % or more at the wavelength of light used in inspection of a pattern formed on the absorber layer.

18. The reflective mask blank as claimed in any one of claims 1 through 17, wherein the reflectivity on the surface of the absorber layer is 20 % or less at the wavelength of light used in inspection of a pattern formed on the absorber layer.

19. The reflective mask blank as claimed in any one of claims 1 through 18, wherein the surface of the absorber layer has a surface roughness of 0.5 nmRms or less.

20. The reflective mask blank as claimed in any one of claims 1 through 19, wherein a substance forming the upper layer of the absorber layer has a refractive index n and an extinction coefficient k at the wavelength of inspection light, where n is 1.5 to 3.5 and k is 0.7 or less.

21. The reflective mask blank as claimed in any one of claims 1 through 20, wherein the thickness of the low-reflectivity layer as the upper layer is selected, with reference to the relationship between the reflectivity of the surface of the absorber layer for inspection light and the thickness of the low-reflectivity layer, so as to minimize the reflectivity of the surface of the absorber layer at the wavelength of the inspection light.

22. The reflective mask blank as claimed in any one of claims 1 through 21, wherein the thickness of the low-reflectivity layer is 5 to 30 nm.

23. A reflective mask obtained by patterning the absorber layer of the reflective mask blank claimed in any one of claims 1 through 22.

24. A method of producing a reflective mask blank comprising a substrate on which a reflective layer for reflecting exposure light in a short-wavelength region including an extreme ultraviolet region and an absorber layer for absorbing the exposure light are successively formed, the absorber layer having an at least two-layer structure including as a lower layer an exposure light absorbing layer comprising an absorber for the exposure light and as an upper layer a low-reflectivity layer comprising an absorber for inspection light used in inspection of a mask pattern, the upper layer being farther from the substrate than the lower layer, wherein:

formation of the lower layer of the absorber layer and formation of the upper layer are continuously carried out within a same deposition chamber.

25. The method of producing a reflective mask blank as claimed in claim 24, wherein the upper layer and the lower layer contain metal elements, respectively, these metal elements being a same metal element.

26. The method of producing a reflective mask blank as claimed in claim 25, wherein the upper and the lower layers of the absorber layer are formed by sputtering, the upper and the lower layers being formed by using a same target containing the metal element and changing a gas used in deposition.

27. A method of producing a reflective mask blank, the method comprising the steps of:

forming, on a substrate, a reflective layer for reflecting exposure light in a short-wavelength region including an extreme ultraviolet region;

forming, on the reflective layer, an exposure light absorbing layer for absorbing the exposure light; and

forming, in the vicinity of a surface of the exposure light absorbing layer, a low-reflectivity layer for inspection light used in inspection of a mask pattern by treating the surface of the exposure light absorbing layer.

28. A method of producing a reflective mask, wherein the reflective mask is obtained by patterning the low-reflectivity layer and the exposure light absorbing layer in the reflective mask blank produced by the method claimed in claim 27.

29. A method of producing a semiconductor, wherein a pattern is transferred onto a semiconductor substrate by the use of the reflective mask claimed in claim 23.

30. A reflective mask blank comprising a substrate on which a multilayer reflective film for reflecting exposure light and an absorber layer for absorbing the exposure light are successively formed, the absorber layer being made of a material containing tantalum (Ta), boron (B), and nitrogen (N), the content of B being 5 at% to 25 at%, the ratio of Ta and N (Ta: N) falling within a range of 8 : 1 to 2 : 7.

31. A reflective mask blank comprising a substrate on which a multilayer reflective film for reflecting exposure light and an absorber layer for absorbing the exposure light are successively formed, the absorber layer containing tantalum (Ta), boron (B), and nitrogen (N), the absorber layer having an amorphous state.

32. A reflective mask blank comprising a substrate on which a multilayer reflective film for reflecting exposure light and an absorber layer for absorbing the exposure light are successively formed, the absorber layer being made of a material containing tantalum (Ta), boron (B), and oxygen (O).

33. The reflective mask blank as claimed in claim 32, wherein the material of the absorber layer further contains nitrogen (N).

34. The reflective mask blank as claimed in any one of claims 31 through 33, wherein the material of the absorber layer contains 5-25 at% boron (B).

35. The reflective mask blank as claimed in any one of claims 32 through 34, wherein the material of the absorber layer has an amorphous state.

36. The reflective mask blank as claimed in any one of claims 30 through 35, wherein the absorber layer has a distribution of composition in which the content of oxygen or nitrogen is gradually increased in the thickness direction towards the surface of the absorber layer.

37. The reflective mask blank as claimed in any one of claims 30 through 36, further comprising a buffer layer formed between the multilayer reflective film and the absorber layer to protect the multilayer reflective film during pattern formation onto the absorber layer.

38. The reflective mask blank as claimed in claim 37, wherein the buffer layer is made of a material containing chromium (Cr).

39. The reflective mask blank as claimed in any one of claims 30 through 38, wherein a contrast between reflected light reflected on a surface of the multilayer reflective film and reflected light reflected on a surface of the absorber layer is 40 % or more at the wavelength of light used in inspection of a pattern formed on the absorber layer.

40. The reflective mask blank as claimed in any one of claims 30 through 39, further comprising a buffer layer formed between the multilayer reflective film and the absorber layer to protect the multilayer reflective film during pattern formation on the absorber layer;

a contrast between reflected light reflected on a surface of the buffer layer and reflected light reflected on a surface of the absorber layer being 40 % or more at the wavelength of light used in inspection of a pattern formed on the absorber layer.

41. The reflective mask blank as claimed in any one of claims 30 through 40, wherein the reflectivity on the surface of the absorber layer is 20 % or less at the wavelength of light used in inspection of a pattern formed on the absorber layer.

42. The reflective mask blank as claimed in any one of claims 30 through 41, wherein the surface of the absorber layer has a surface roughness of 0.5 nmRms or less.

43. A reflective mask obtained by patterning the absorber layer of the reflective mask blank claimed in any one of claims 30 through 42.

44. A method of producing a semiconductor, wherein a pattern is transferred onto a semiconductor substrate by the use of the reflective mask claimed in claim 43.